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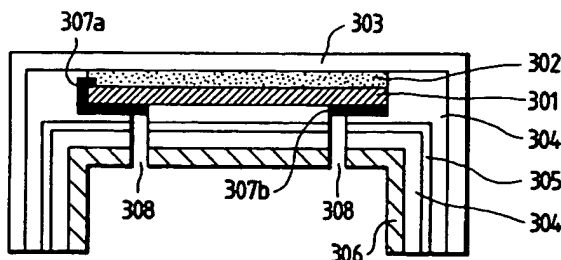
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⑤4 Light-transmissive resin sealed semiconductor and production process thereof.

⑤7 The object is to provide a light-transmissive resin sealed semiconductor that is excellent in weatherability, heat resistance and fire retardancy, limits the performance deterioration of photovoltaic element for a long term due to moisture permeation to an minimum extent, has rubber elasticity necessary for protecting the semiconductor element, and has a surface covering material that is incombustible or fire retardant. This object is achieved by a construction wherein a covering material provided on the surface of the incident light side of photovoltaic element 101, comprises a transparent filler 102 that is a cross-linked multi-component copolymer containing fluorine and vinylidene fluoride and hexafluoropropylene as the major components.



BACKGROUND OF THE INVENTIONField of the invention

5 The present invention relates to a light-transmissive resin sealed semiconductor and a production process thereof, and specifically relates to a solar cell module and a production process thereof. The solar cell module comprises a photoelectric transducer in which a semiconductor photoactive layer as a light converting element and a conductive layer are formed on a substrate having a conductive surface. The solar cell module is particularly excellent in heat resistance and fire retardancy.

Related Background Art

10 Nowadays, environmental problems have been noted worldwide increasingly. In particular, global warming caused by CO₂ emission has been seriously concerned, and the need for clean energy that does not exhaust CO₂ becomes stronger. Solar cells are expected for a clean energy source because of safety and easiness in handling.

There are various types of solar cells; typical examples include a crystalline silicon solar cell, polycrystalline silicon solar cell, amorphous silicon type solar cell, copper-indium-selenide solar cell, and compound semiconductor solar cell. Among them, a thin film crystalline silicon solar cell, compound semiconductor solar cell and amorphous silicon type solar cell, have been made subjects of R&D actively in various fields since large area may be realized at a relatively low cost.

In particular, a thin film solar cell, typically represented by an amorphous silicon type solar cell in which silicon is deposited on to a metal substrate having conductive surface and a transparent conductive layer is formed thereon, is light weight and excellent in impact resistance and flexibility, and is considered to be a hopeful module form among the mentioned solar cells. A solar cell module that is flexible requires protection for internal solar cells by covering the surface of incident light side with a transparent covering material, unlike the case of silicon deposition on a glass substrate.

As for such surface covering material, a construction may be considered wherein a transparent thin film of a fluoride polymer such as a fluororesin film or fluororesin coating is provided on the topmost surface and various transparent organic thermoplastics are provided inward. This construction is based on the facts that a fluoride polymer is excellent in weatherability and water repellency making the reduction of conversion efficiency of the solar cell module smaller caused by decrease of the light transmittance due to yellowing, cloudiness or fouling of the surface and that a transparent organic thermoplastic is inexpensive and a large amount may be used for filler protecting a photovoltaic element which is a semiconductor.

35 Fig. 6 shows an example of solar cell module. This solar cell module comprises a thin film layer 601 of a fluoride polymer, a thermoplastic transparent organic resin 602, a photovoltaic element 603 and an insulating layer 604. In the construction of this solar cell module, the organic resin of the light receiving surface is also used in the back surface.

More specifically, fluoride polymer thin film layer 601, is composed of a fluororesin film such as an ethylene-tetrafluoroethylene copolymer (ETFE) film or polyvinyl fluoride (PVF) film; thermoplastic transparent organic resin 602 is produced from ethylene-vinyl acetate copolymer (EVA), butyral resin or the like; and insulating layer 604 is selected from various organic resin films including nylon film and aluminum laminated Tedlar film. In this solar cell module, thermoplastic transparent organic resin 602 functions as the adhesive that adheres photovoltaic element 603 to fluororesin film 601 and to insulating layer 604 and as the filler that protects the solar cells against outward scratch and impact.

However, in a solar cell module with such structure as described above having a surface covering material, the thermoplastic transparent organic resin used as the filler becomes cloudy due to partial gelation of the resin during outdoor exposure for as long as 20 years or yellowing occurs in the resin by increase of conjugated double bonds in the chemical bonds; these inevitably cause the decrease of light transmittance of the resin and conversion efficiency of the solar cell module. This problem is more serious in application where the module is incorporated with roofing or other construction material and the module temperature is more elevated.

Furthermore, acceleration of the yellowing is known when the module is subjected to the condition exceeding 80 degrees or higher in the case of EVA filler for example. In the case of butyral resin filler, hygroscopicity is relatively high and moisture easily attacks defective parts of photovoltaic elements. The moisture and electric field of photovoltaic element might cause a metal composing the collecting electrode or the like to be grown by repetition of ionization and precipitation; when such reactions proceed further, short circuits may be formed among the photovoltaic elements and separated electric charge becomes

unable to be led to outward lowering the conversion efficiency. Butyral resin has additional problem that the transparency is lost under high temperature and high humidity conditions.

For these problems, Japanese Patent Application Laid-Open No. 4-76229 discloses a protective film having a component of a derivative of resin which comprises perfluoroalkylene group and active hydrogen for a CdS/CdTe type solar cell formed on a substrate and for the substrate. As for the resin comprising perfluoroalkylene group and active hydrogen, a product (trade name: Lumiflon) of Asahi Glass Co., Ltd.) is mentioned. According to Japanese Patent Application Laid-Open No. 4-76229, Lumiflon is a fluorine-contained polymer having number average molecular weight from 20,000 to 80,000 normally and contains perfluoroalkylene group and pendant active hydrogen (more specifically OH group), which produces a cross-linked polymer (derivative) by reaction with melamine or a compound having isocyanate group.

In addition, Japanese Patent Application laid-Open No. 4-76229 also discloses, in the description of the example, a protective film excellent in moisture resistance obtained by cross-linking mentioned Lumiflon with an isocyanate or a resol type phenolic resin. However, the coating process disclosed therein requires to place the coating on the topmost surface of a solar cell; that is, the pot life of the resin that has been mixed with the mentioned cross-linking is generally short and no one is known having a long after the cross-linking is mixed. In practice, the pot life is extended by protecting the isocyanate with a blocking agent. However, adoption of the coating structure, as mentioned above, where surface film is laminated to the resin causes such a problem that the cross-linking reaction does not proceed because the blocking agent is not dissociated and, thus, not volatilized during resins cross-linking.

On the other hand, lamination of the surface film after the cross-linking of resin is difficult since the cross-linked product lacks tackiness and adhesiveness. Furthermore, when the cross-linking agent is melamine, no effective blocking agents are known. Thus, the resin mentioned above should be used on the topmost surface of the solar cell module. However, the surface hardness of the resin is low and easily damaged by outdoor sand and dust, which will accumulate on the damaged part; thereby the sunlight might be shielded. Depending on the manner of the resin lamination, simple application of coating might create pin holes and might include dust; moisture and oxygen may penetrate into the photovoltaic element. It is known furthermore that thick coating with a material having rubber elasticity to protect solar cell element is effective for preventing damage of solar cell element caused by bending and difference of thermal expansion due to change of temperature; however, making the coating resin thick is substantially difficult by application of coating, may damage the element, and does not give sufficient protection for concave and convex parts in the solar cell surface brought by electrical wirings or others. In addition, Lumiflon mentioned above has not rubber elasticity.

Thus, any organic surface coating materials have not been known actually that have both weatherability and moisture resistance at a high level.

EVA has been exclusively used because of 1) long shelf life, 2) relatively excellent weatherability, 3) adhesiveness to various substrates, 4) easiness of cross-linking, and 5) inexpensiveness; however, EVA is easily flammable as many other transparent organic resins. The flammability is undesirable for application in dense residential areas not only in the case of solar cell modules installed in integration of roofing materials but also in the case of solar cell arrays installed on a frame. Turning solar cell modules into flame resistant or retardant is predicted to be very important for making solar cell modules prevalent in future in common housing.

Covering with glass would be most suitable for overcoming these problems; thus, sealing solar cells with glass has been tried numerously. However, coating with glass has such problems as flexibility, impact resistance, weight reduction, and cost. In addition, even with glass coating, solar cell elements might fall to the back side by flame when the backside is not made of heat resistant materials; it cannot be incombustible material.

In view of these situations, fluororubber may be a candidate for high performance filler for solar cells.

In a report, in 1979, of Jet Propulsion Laboratory, US Department of Energy, titled "Investigation of Test Methods, Materials, Properties and Processes for Solar Cell Encapsulation.", use of a fluororubber (Trade name: Viton, manufactured by Du Pont) is disclosed for a sealing material of solar cell modules. However, with Viton mentioned above, it is reported in the cited report that yellowing and peeling, due to poor adhesion, from the surface material occur in the weatherability test using Sunshine Weather-O-Meter. Thus, even now, commercial application of fluororubber to solar cell sealing is not under way.

In the case of Viton above, effective cross-linking is made with a polyamine or polyol; it is known to add various metal oxides and salts, as acid receptors, which neutralize acidic substance generated in the cross-linking process of the fluororubber that is a type of polyol or polyamine cross-linking. For example, lead oxide or calcium hydroxide is added to cross-link; however, known acid receptors in general including polyol and polyamine are not transparent, thus, this type of cross-linked fluororubber is not suitable for solar

cells. That is, the fluororubber that is to be cross-linked with polyamine or polyol becomes optically opaque-rubber when employed as the filler of solar cells; thereby, the conversion efficiency of solar cells is decreased. Even if the acid receptor is transparent, reactions caused by removal of HF occur and the resultant fluororubber becomes brown. In addition, since the cross-linked site is bromine, the weatherability is poor; this is considered to be the reason for yellowing in the accelerated test by Sunshine Weather-O-Meter mentioned above.

On the other hand, when the above-mentioned fluororubber is used without cross-linking, optically transparent filler is obtained surely; however, temperature elevation by incident light becomes a problem. That is, the temperature of solar cell modules located on roof or provided in a hot area is known to become 80 degree or higher and the filler undergoes creep when used in such conditions for a long period. In other words, the fluororubber mentioned above becomes out of the right place of photovoltaic elements because not cross-linked and finally, the covering material may peel off.

Therefore, an object of the present invention is to overcome these problems and provide a solar cell module and production process thereof having a surface covering material, more specifically, a filler resin filling the space between the film of light receiving surface and the elements, which covering material is excellent in weatherability and heat resistance, has excellent adhesiveness to the surface film, limits deterioration of long term performance of the photovoltaic elements by moisture permeation to a minimum extent, has enough rubber elasticity with a sufficient thickness to protect solar cell elements, and is fire retardant or incombustible.

SUMMARY OF THE INVENTION

The present inventors have found the following solar cell module is best as a result of ardent research and development.

That is, the solar cell module according to the present invention in which a covering material provided on the surface of the incident light side of a photovoltaic element and comprising two layers comprising a transparent filler and a transparent surface sheet provided at upmost outer surface of the filler wherein the filler comprises a cross-linked multi-component copolymer (copolymer that has two or more sorts of comonomer) containing fluorine in an amount of 60 to 80%, and containing vinylidene fluoride and hexafluoropropylene as the major components, and the surface sheet comprises a film of 40 to 60% fluorine content.

The production process of solar cell module according to the present invention is to produce the solar cell module having the constitution as mentioned above and comprises the steps as described hereinafter.

The solar cell module, according to the present invention, of the constitution as mentioned above has the following functions.

(1) A covering material is obtained that has excellent fire retardancy even with a thickness that gives satisfactory mechanical strength. It is to be noted here that EVA used conventionally has a heat of combustion as high as 11 Kcal/g; once the covering material is fired, self-extinguishing cannot be expected by EVA itself. For improving such character of combustion, countermeasures have been taken by decreasing the amount of EVA; this means to decrease the thickness of EVA, which in turn decreases the mechanical strength and obviously decrease the resistance to external force.

(2) The covering material in accordance with the present invention is essentially excellent in weatherability, probably because of using a fluororesin. Yellowing does not occur during the use for a long period as occurs in conventional EVA and the conversion efficiency does not lower in the solar cell elements.

(3) The filler in accordance with the present invention is essentially excellent in moisture resistance since the fluorine content is 60% or more. Thus, moisture does not attack the solar cell elements easily unlike conventional polyvinyl butyral resin which absorbs moisture under humid conditions, and short cut circuits in the solar cell elements rarely occur. Furthermore, devitrification, which is the highest defect of polyvinyl resins, does not occur, and the conversion efficiency of solar cell elements does not lower.

(4) since a cross-linked product of a copolymer containing more than two sorts of comonomer, the problem of peeling due to softening of the filler when used at a high temperature is prevented. Since a fluororesin is used in the filler according to the present invention, the surface covering material would be essentially excellent in heat resistance. Unlike the case of using conventional EVA in which yellowing is accelerated after the antioxidant or others used in combination is volatilized during the service at a high temperature, the conversion efficiency of the solar cell elements does not lower. Furthermore, the adhesiveness will be improved when a coupling agent is included in the filler.

(5) The covering is excellent in weatherability since ethylene tetrafluoride-ethylene copolymer is employed in the surface film, which is excellent in weatherability by itself and increases the weatherability combined with the fluororesin in the filler.

(6) In addition, covering excellent in workability at post-treatment results if the surface film is not subjected to a drawing treatment and composed of ethylene tetrafluoride-ethylene copolymer; that is, crack or breakage in the surface film is prevented when the end parts of the solar cell modules are bent in workings.

BRIEF DESCRIPTION OF THE DRAWINGS

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Fig. 1 is a schematic sectional view illustrating an example of the light transmitting resin sealed semiconductor device;

Figs. 2A and 2B show examples of the basic construction of the photoelectric transducer used in the solar cell module shown in Fig. 1 and Fig. 2A is a schematic sectional view and Fig. 2B is an upper plan view;

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Fig. 3 is a schematic sectional view of a solar cell module according to the present invention;

Fig. 4 is a schematic sectional view of another solar cell module according to the present invention;

Fig. 5 is a schematic sectional view of a solar cell module shown for the purpose of comparison; and

Fig. 6 is a schematic sectional view of another solar cell module shown for the purpose of comparison.

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DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now, the light transmitting resin sealed semiconductor according to the present invention is explained in details referring the drawings.

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Fig. 1 shows outline of the construction of a solar cell module according to the present invention. This solar cell module comprises photovoltaic element 101 which is a photoelectric transducer, surface filler 102, surface film 103, back surface filler 104, back surface covering film 105, and reinforcing plate 106. In this solar cell module, light from outward enters to surface film 103 and reaches photovoltaic element 101; the electromotive force generated in photovoltaic element 101 is taken out to outwards to an output terminal (not shown).

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Photovoltaic element 101

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In photovoltaic element 101 in the present invention, a semiconductor photoactive layer is formed as the light converting member at least on a conductive substrate and an example is shown in Figs. 2A and 2B for its schematic structures. As shown in Figs. 2A and 2B, photovoltaic element 101 comprises substrate 201 having a conductive surface, back surface reflective layer 202, semiconductor photoactive layer 203, transparent conductive layer 204, and collecting electrode 205.

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Conductive substrate 201

Conductive substrate 201 is the substrate of photovoltaic element and at the same time serves as the lower electrode. Conductive substrate 201 may be made from silicon, tantalum, molybdenum, tungsten, stainless, aluminum, copper, titanium, carbon sheet, lead plated steel plate, and resin films and ceramics formed conductive layer. On conductive layer 201, a metal layer or metal oxide layer, or a metal layer and metal oxide layer may be formed as back surface reflective layer 202. The metal layer may be made from Ti, Cr, Mo, W, Al, Ag, Ni and Cu. The metal oxide layer may be made from ZnO, TiO₂, SnO₂ and ITO. Examples of forming method of the metal layer and metal oxide layer mentioned above include resistance heating vapor deposition, electron beam vapor deposition and sputtering.

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Semiconductor photoactive layer 203

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Semiconductor photoactive layer 203 is the part where photoelectric conversion is performed. Examples of material for semiconductor photoactive layer 203 include pn junction type polycrystalline silicon, pin junction type amorphous silicon and homologues (including fine crystals, a-SiGe and a-SiC), and compound semiconductors such as CuInSe₂, CuInS₂, GaAs, CdS/Cu₂S, CdS/CdTe, CdS/InP, and CdTe/Cu₂Te. The forming method of semiconductor photoactive layer 203 is sheeting of melted silicon or heat treatment of amorphous silicon for the case of polycrystalline silicon; plasma CVD is applied for amorphous silicon

using, as the starting material, silane gas or what controls the conductivity such as diborane and phosphine gas for the case of amorphous silicon; and ion plating, ion beam deposition, vacuum evaporation, sputtering and electrodeposition are used for the case of compound semiconductor.

5 Conductive layer 204

Conductive layer 204 serves as one side of the electrodes of the solar cell. Examples of the material for conductive layer 204 at the side of incident light include In_2O_3 , SnO_2 , $\text{In}_2\text{O}_3\text{-SnO}_2$ (ITO), ZnO , TiO_2 , Cd_2SnO_4 and crystalline semiconductor layer where impurity is doped in a high concentration. Examples of forming method of transparent semiconductor layer 204 include resistance heating vapor deposition, sputtering, spraying, CVD and impurity diffusion.

On transparent conductive layer 204, collecting electrode 205 (grid) may be provided in a form of grating or the like for the purpose of collecting the electric current efficiently. Examples of the material for collecting electrode 205 include: Ti, Cr, Mo, W, Al, Ag, Ni, Cu, Sn, and their alloys; and various conductive pastes such as silver paste. Examples of forming method of collecting electrode 205 include: sputtering using mask pattern; resistance heating vapor deposition; CVD; a process comprising vapor depositing a metal film in the whole surface and removing unnecessary thereafter by etching to make a pattern; a process to form a grid electrode pattern directly by photo CVD; a process comprising forming the mask of negative pattern of a grid electrode and plating thereafter; and a process of printing a conductive paste and allowing to cure. The conductive paste used usually contains fine powder of silver, gold, copper, nickel or carbon dispersed in a binder polymer. Examples of the binder polymer include resins such as polyester, epoxy, acrylic, alkyd, polyvinyl acetate, rubbery, urethane and phenolic.

Output terminal 206a, 206b

Finally, output terminal 206 for taking out the electromotive force is installed to conductive substrate 201 and collecting electrode 205. In this procedure, a metallic body such as copper tab is joined to conductive substrate 201 by spot welding or soldering, and a metallic body is electrically connected to collecting electrode 205 with a conductive paste or solder.

Photovoltaic element 101 prepared as mentioned above is connected in series and/or parallel depending on desired voltage or current. The photovoltaic element may be integrated on an insulated substrate to get voltage or current as desired.

Back surface covering film 105

Back surface covering film 105 is provided for the purpose of securing electric insulation between the conductive substrate of photovoltaic element 101 and outward. The material is preferably what is able to secure enough electrical insulation against the conductive substrate, can resist thermal expansion and contraction, and has durability for a long period and flexibility. Suitable examples for the film include nylon and polyethylene terephthalate.

Back surface filler 104

Back surface filler 104 is to connect photovoltaic element 101 with back surface covering film 105. Preferable material for back surface filler 104 is what is able to secure adhesiveness with the conductive substrate, resistant against thermal expansion and contraction, excellent in long term durability, and flexible. Examples of suitable material include hot melt materials such as EVA and polyvinyl butyral, double coated tape, and flexible epoxy adhesives.

Cross-linking is preferable for making the adhesion firm at a high temperature when the solar cell module is to be used at elevated temperatures such as a type integrated with roofing material. It is common to use an organic peroxide for cross-linking EVA and the like.

Reinforcing plate 106 may be stuck to outside of back surface covering film 105 for enhancing the mechanical strength of solar cell module or for preventing distortion and deflection caused by temperature change. Steel plate, plastic plate, or glass fiber reinforced plastic (FRP) plate may be, for example, employed as reinforcing plate 106

Surface filler 102

Now, surface filler 102 used in the present invention is explained in details.

Surface filler 102 is necessary for covering the concave and convex of photovoltaic element 101 and
 5 securing the adhesiveness to surface film 103; thus weatherability, adhesiveness and heat resistance are
 required for surface filler 102. It is desirable for satisfying these requirements that the main resin
 component is a cross-linked copolymer that has two or more sorts of comonomer (multi-component
 copolymer), contains fluorine in an amount corresponding to 60 to 80%, and contains vinylidene fluoride
 10 and hexafluoropropylene as the major components. When the fluorine content in the multi-component
 copolymer is 60% or more, the weatherability of the fluororesin develops sufficiently and the fire retardancy
 can be realized as well. On the other hand, when the fluorine content in the multi-component copolymer is
 80% or less, enough adhesiveness can be maintained in the interface of the transparent electrode on the
 surface of photovoltaic element and the surface film. If the adhesiveness is insufficient, the reliability of solar
 cell module is impaired, i.e. peeling might occur during the service for a long period and moisture might
 15 penetrate. It might be considered to prevent such peeling by heating at a temperature of 240 °C or higher
 when thermal adhesion is made; however, this might damage the solar cell element by the heat and cannot
 be adopted.

The ratio of comonomers, vinylidene fluoride (hereinafter may be abbreviated as VDF) to hexa-
 fluoropropylene (hereinafter may be abbreviated as HFP), is set so that the copolymer is a rubbery
 20 polymer. Usually, VDF-HFP copolymer becomes a good rubber when VDF content is 50 to 80 molar %.
 When the VDF content is high, the glass transition point tends to be lowered and the low temperature
 resistance is improved. However, VDF unit tends to coagulate or crystallize due to hydrogen bond and
 introduction of HFP unit in an amount exceeding a certain level is necessary for getting a highly transparent
 amorphous rubber that is suitable for covering of solar cells. Thus, introduction of HFP unit in an amount of
 25 about 20 molar % or more is preferred for providing sufficient rubber elasticity and transparency suitable for
 the usage in the present invention.

Furthermore, a terpolymer is applicable for the purpose of improving heat resistance and chemical
 resistance by adding tetrafluoroethylene (TFE) to VDF and HFP. In this case, the physical properties are
 improved while the rubber elasticity is maintained by replacing VDF unit with TFE unit; the ratio of
 30 replacement is preferably 1 to 30 molar %.

Now, the organic peroxides employed for cross-linking the filler of the present invention are explained in
 details. Cross-linking with an organic peroxide is performed by that free radicals generated from the organic
 peroxide remove hydrogen and/or halogen atoms to form C-C bond. Known activation processes for organic
 peroxides are thermal decomposition, redox decomposition and ionic decomposition and thermal de-
 35 composition is most preferred in general.

On the basis of chemical structure, the organic peroxides may be classified into the categories of:
 hydroperoxides, dialkyl(allyl)peroxides, diacylperoxides, peroxyketals, peroxyesters, peroxycarbonates, and
 ketoneperoxides.

Examples of hydroperoxides include t-butylperoxide, 1,1,3,3-tetramethylbutylperoxide, p-men-
 40 thanehydroperoxide, cumenhydroperoxide, p-cymenehydroperoxide, diisopropylbenzeneperoxide, 2,5-
 dimethylhexane-2,5-dihydroperoxide, cyclohexaneperoxide and 3,3,5-trimethylhexanoneperoxide.

Examples of dialkyl(allyl)peroxides include di-t-butylperoxide, dicumylperoxide and t-butylcumylperox-
 ide.

Examples of diacylperoxides include diacetylperoxide, dipropionylperoxide, diisobutyrylperoxide, dioc-
 45 tanoylperoxide, didecanoylperoxide, dilauroylperoxide, bis(3,3,5-trimethylhexanoyl)peroxide, benzoylperox-
 ide, m-toluylperoxide, p-chlorobenzoylperoxide, 2,4-dichlorobenzoylperoxide and peroxy succinate.

Examples of peroxyketals include 2,2-di-t-butylperoxybutane, 1,1-di-t-butylperoxycyclohexane, 1,1-di-(t-
 butylperoxy)-3,3,5-trimethylcyclohexane, 2,5-dimethyl-2,5-di-(t-butylperoxy)hexane, 2,5-dimethyl-2,5-di-(t-
 butylperoxy)hexyne-3, 1,3-di(t-butylperoxyisopropyl)benzene, 2,5-dimethyl-2,5-dibenzoylperoxyhexane, 2,5-
 50 dimethyl-2,5-di(peroxybenzoyl)hexyne-3, and n-butyl-4,4-bis(t-butylperoxy)valerate.

Examples of peroxyesters include t-butylperoxyacetate, t-butylperoxyisobutylate, t-butylperox-
 ybivalerate, t-butylperoxyneodecanoate, t-butylperoxy-3,3,5-trimethylhexanoate, t-butylperoxy-2-ethylhex-
 anoate, (1,1,3,3-tetramethylbutylperoxy)2-ethylhexanoate, t-butylperoxylaurate, t-butylperoxybenzoate, di(t-
 butylperoxy)adipate, 2,5-dimethyl-2,5-di(peroxy-2-ethylhexanoyl)hexane, di(t-butylperoxy)isophthalate, t-
 55 butylperoxymaleate, and acetylcyclohexylsulphonylperoxide.

Examples of peroxycarbonates include t-butylperoxyisopropylcarbonate, di-n-propylperoxydicarbonate,
 di-sec-butylperoxydicarbonate, di(isopropylperoxy)dicarbonate, di(2-ethylhexylperoxy)dicarbonate, di(2-
 ethoxyethylperoxy)dicarbonate, di(methoxypropylperoxy)carbonate, di(3-methoxybutylperoxy)dicarbonate,

and bis-(4-t-butylcyclohexylperoxy)dicarbonate.

Examples of ketoneperoxides include acetylacetoneperoxide, methylethylketoneperoxide, methylisobutylketoneperoxide, and ketoneperoxide.

Other structures such as vinyltris(t-butylperoxy)silane are known as well.

5 The amount of the above-mentioned organic peroxides to be added is 0.5 to 5 parts by weight per 100 parts by weight of the filler resin. The organic peroxides may be used in combination of the filler to proceed cross-linking and bond under pressure with heat. The heating temperature and period of time is to be set according to the temperature of the thermal decomposition of respective organic peroxides. Generally, application of heat and pressure is to be finished at the temperature and period of time where the thermal
10 decomposition proceeds 90% or more, preferably 95% or more.

For the purpose of proceeding the cross-linking reaction efficiently, use of triallylisocyanurate (TAIC), which is called a cross-linking auxiliary agent, is preferred. The amount of the cross-linking auxiliary agent is generally 1 to 5 parts by weight per 100 parts by weight of the filler resin.

15 While the material used in the present invention as the filler is excellent in weatherability, an ultraviolet absorber may be used in combination for the purpose of improving the weatherability further and protecting the layer below (from the side of incident light) the filler. Any known ultraviolet absorbers may be used, however, a low volatile ultraviolet absorber is preferred in consideration of the environment where the solar cell module is served. Simultaneous addition of a light stabilizer with the ultraviolet absorber will provide a filler film stabilized more against light.

20 A fluororesin in general is supposed to be relatively poor in heat resistance compared to the weatherability; addition of an antioxidant may be possible.

When the solar cell module is supposed to serve under severer circumstances, it is preferred to improve the adhesiveness of the filler to the photovoltaic element or to the upmost surface film. For this purpose, a silane coupling agent or organic titanate compound may be added to the filler. The amount to be
25 added in this case is preferably 0.1 to 3 parts by weight, more preferably 0.25 to 1 parts by weight, per 100 parts by weight of the filler resin. Examples of silane coupling agents include vinyltrichlorosilane, vinyltris(β -methoxyethoxy)silane, vinyltriethoxysilane, vinyltrimethoxysilane, γ -methacryloxypropyltrimethoxysilane, β -(3,4-epoxycyclohexyl)ethyltrimethoxysilane, γ -glycidoxypropylmethyldiethoxysilane, N- β (aminoethyl) γ -aminopropyltrimethoxysilane, N- β (aminoethyl)- γ -aminopropylmethyldimethoxysilane, γ -aminopropylmethyl-
30 dimethoxysilane, γ -aminopropyltriethoxysilane, N-phenyl- γ -aminopropyltrimethoxysilane, γ -mercaptopropyltrimethoxysilane, and γ -chloropropyltrimethoxysilane.

Nonwoven materials such as glass fiber may be incorporated for the purpose of increase the strength of the filler.

35 Surface film 103

Upmost surface film 103 used in the present invention is positioned in the upmost layer of the solar cell module and required to have performance that will guarantee long term reliability in outdoor exposure of the solar cell module; the required performance includes weatherability, water repellancy, resistance to fouling,
40 and mechanical strength. Suitable material for the purpose of the present invention is poly(vinylidene fluoride) resin or ethylene tetrafluoride-ethylene copolymer. While poly(vinylidene fluoride) is superior in respect of weatherability, tetrafluoride-ethylene copolymer is superior in respect of compatibility of weatherability and mechanical strength. Corona treatment and plasma treatment to the surface film are preferable for improving the adhesiveness between the upmost film and filler.

45 As a means of fixing the solar cell module according to the present invention, for example when installed on a roof, fabrication with bending the ends of the solar cell module may be made.

Uniaxially drawing is made for some ethylene tetrafluoride-ethylene copolymers for improving the mechanical strength of the upmost film; characteristic of such film is lower breaking elongation and higher
50 breaking tensile strength in the drawn direction than the direction not drawn or the film that is not drawn.

When bending fabrication is made using the uniaxially drawn film, breaking or crack tends to develop at the bending part. It has been necessary for preventing the defect associated with the bending to bend with a large curvature or at an elevated temperature; thus, troublesome work has been necessary for the bending work for a long period of time. According to the present invention, it is found now that use of the film not drawn makes free from such troublesome work.

55 Now, the process for producing the solar cell module is explained using the photovoltaic element, filler, surface film, and back surface covering material mentioned above is explained.

As the method of covering the light receiving surface of photovoltaic element 101 with surface filler 102, there are: a method of evaporating solvent after coating the filler that is dissolved in a solvent; a method

comprising forming a filler layer on the surface film beforehand and sticking it under pressure on the photovoltaic element with heating; and a method comprising forming the filler in a sheet form beforehand and sticking it under pressure on the photovoltaic element with heating.

In the case of dissolving filler 102 in solvent as described above, the filler is mixed simultaneously with various kinds of additives such as a cross-linking agent, silane coupling agent, UV absorbing agent; antioxidant and the like. The mixture is coated on the photovoltaic element and allowed to dry at such temperature that cross-linking reaction may not go on. Likewise, in the case of forming the filler in a sheet form, additives are mixed with the filler beforehand; it is required to adjust the forming temperature at such temperature that cross-linking reaction may not go on.

In the case that the filler is formed preliminarily either on photovoltaic element 101 or on surface film 103, a solar cell module is obtained by superimposing back surface filler 104 and back surface covering film 105 on the back surface and sticking under pressure with heat and by superimposing surface film 103 on the front surface and sticking under pressure with heat. In the case of providing reinforcing plate 106, it is enough to pressurize and adhere the plate to back surface covering film 105 via back surface filler 104 or a different adhesive. This procedure may be taken simultaneously with or after the process described above. In the case that the filler is formed in a sheet form, it may be inserted between photovoltaic element 101 and surface film 103 to be likewise thermally adhered under pressure to produce a solar cell module. The temperature of heating at the adhering step under pressure should allow the cross-linking reaction to proceed satisfactorily and the period of time of this step should also satisfy this requirement.

The method of adhesion under pressure may be vacuum lamination, roll lamination and the like. The present invention is explained in details by the following Examples.

Example 1

A procedure to prepare amorphous silicon (a-Si) solar cell (photovoltaic element) is explained by using schematic model of Figs. 2A and 2B.

An Al layer (film thickness: 5000 Å) and ZnO layer (film thickness: 5000 Å) as back surface reflecting layer 202 were formed in this order on a cleaned stainless steel substrate (conductive substrate 201) by a sputtering method. As the next step, n type a-Si layer was made from a mixture gases of SiH₄, PH₃ and H₂, i type a-Si layer was made from a mixture gases of SiH₄ and H₂, and p type microcrystal μ c-Si layer was made from the mixture gases of SiH₄, BF₃ and H₂ respectively by a plasma CVD method. Formed was a tandem type a-Si (amorphous silicon type) photoelectric converting semiconductor layer (photoactive semiconductor layer 203) consisting of n layer of 150 Å film thickness/i layer of 4000 Å film thickness/p layer of 100 Å film thickness/n layer of 100 Å film thickness/i layer of 800 Å film thickness/p layer of 100 Å film thickness. Then, a thin film, as transparent conductive layer 204, of In₂O₃ (film thickness: 700 Å) was formed by vaporizing In under O₂ atmosphere by resistance heating method. Further, a grid electrode for electric collector (electric collecting electrode 205) was formed by a screen printing using a silver paste. Finally, a copper tab as minus side terminal 206b was attached on the stainless steel substrate by using stainless steel solder 208. As plus side terminal 206a, a silver foil tape was attached on electric collecting electrode 208 by using conductive adhesive 207 to provide the output terminal. A photovoltaic element was thus produced.

A process for producing a solar cell module from this photovoltaic element by covered is explained referring Fig. 3.

Into a solvent which is a mixture of acetone and methyl ethyl ketone in the ratio of 3:2, 100 parts by weight of a VDF-HFP fluororubber (a copolymer of about 80 molar % VDF and about 20 molar % HFP, fluorine content 66 % : iodine cross-linking site), 1.5 parts by weight of 2,5-dimethyl-2,5-di(tertiary butyl peroxide) hexane as the crosslinking agent, 4.0 parts by weight of triaryl isocyanurate as the auxiliary cross-linking agent, 0.5 parts by weight of γ -methacryl oxypropyl trimethoxy silane as the silane coupling agent, 0.3 parts by weight of 2-hydroxy-4-n-octoxy benzophenone as the UV absorbing agent, and 0.2 parts by weight of tris(mono-nonylphenyl) phosphite as the antioxidant were dissolved to prepare a 50% by weight solution of the fluororubber. The light receiving surface of photovoltaic element 301 was coated with the solution and dried at 60 °C for 30 minutes. This process of coating/drying was repeated until filler layer 302 of about 200 μ film thickness was formed.

To make module

On the incident light side surface of photovoltaic element 301 covered with the above-mentioned filler, surface film 303 (film thickness: 50 μ) of non-oriented ETFE film having one surface treated by corona

discharge was provided in such a manner that the treated surface may contact the filler; on the back side, filler 304 (of 460 μ film thickness, manufactured by Mobay) containing, EVA sheet, back surface coating film 305 composing of a nylon film (of 63.5 μ film thickness, trade name: Dartech, manufactured by du Pont), reinforcing plate 306 made of Galvarium steel sheet (galvanized steel sheet) were superimposed so that the order was photovoltaic element 301/back surface filler (EVA) 304/back surface coating film (nylon) 305/back surface filler (EVA) 304/reinforcing plate (Galvarium steel sheet) 306. A solar cell module with light receiving surface covered with the fluororubber was produced by heating at 160 °C for 20 minutes while degassing under pressure by a vacuum lamination device. The output terminal was set on the back surface of photovoltaic element beforehand so that, after lamination, the output might be introduced from the output terminal outlet opened beforehand in the Galvarium sheet iron. Finally, extra Galvarium sheet iron protruded from the photovoltaic element was bent together with laminated materials at 90 ° to the back surface side so that module strength and the easiness in installation as a roof incorporated type module might be improved.

The solar cell module produced by above process was evaluated in terms of the items described hereinafter.

Example 2

Example 2 according to the present invention is explained by referring Fig. 4.

A photovoltaic element was prepared in the same way as Example 1.

To 100 parts by weight of the fluororubber same as Example 1, 1.5 parts by weight of 2,5-dimethyl-2,5-di(tertialbutylperoxy)hexane as the cross-linking agent, 4 parts by weight of triallylisocyanurate(TAIC) as the cross-linking auxiliary agent, 0.5 parts by weight of γ -methacryloxypropyltrimethoxysilane as the silane coupling agent were blended to prepare a fluororubber sheet. That is, the VDF-HFP fluororubber was wound to kneading rolls warmed at 70 to 80 °C, thereafter, TAIC and the silane coupling agent was charged by small portions; kneading was performed; the kneaded product was removed from the rollers once; the rollers were allowed to cool to 50 °C, then the rubber was wound to the rolls; and the cross-linking agent was added therein and allowed to be kneaded uniformly. From there, a portion of the product was taken out and formed into a sheet of about 2 mm thickness.

Above fluororubber sheet 402 was provided on the surface of photovoltaic element 401; thereon, surface film 403 (50 microns thickness) comprising not drawn ETFE one surface of which was subjected to corona treatment was superimposed so that the treated surface became in contact with the filler; and the lamination and post treatment were made in the same way as Example 1 to get a solar cell module. Reference numerals 401, 403 to 408 in Fig. 4 correspond to 301, 303 to 308 in Fig. 3 respectively.

Example 3

A solar cell module was produced in the same manner as Example 1 except that the fluororubber used was a copolymer VDF-HFP fluororubber containing 71% of fluorine, about 50 molar % of VDF and about 50 molar % of HFP (cross-linked site: bromine).

Example 4

A solar cell module was produced in the same manner as Example 2 except that the fluororubber used was a copolymer VDF-HFP fluororubber containing 71% of fluorine, about 50 molar % of VDF and about 50 molar % of HFP (cross-linked site: bromine).

Example 5

A solar cell module was produced in the same manner as Example 1 except that the covering material was of the same structure as Example 2 replacing the coating of the fluororubber solution on photovoltaic element 301 with the coating on surface film 303.

Comparative Example 1

Comparative Example 1 is explained referring Fig. 5 for the purpose of demonstrating the effects of the Examples performed more clearly.

Surface filler 502a (manufactured by Mobay, 460 microns thickness) comprising EVA sheet, surface covering film 503 (50 microns thickness) comprising not drawn ETFE film one surface of which was

provided on the light receiving surface side of photovoltaic element 501 prepared in the same way as mentioned above; in the back side, reinforcing plate 504 that is composed of back surface filler 502b comprising EVA sheet (manufactured by Mobay, 460 microns thickness), back surface film 503 comprising nylon film (manufactured by Du Pont, trade name Dartech, 63.5 microns thickness), and Galvarium steel sheet (zinc plated steel sheet) was provided; and the order of superimposition was surface covering film (ETFE). 503/surface filler (EVA) 502a/photovoltaic element 501/back surface filler (EVA) 502b/back surface covering film (nylon) 503/back surface filler (EVA) 502b/reinforcing plate (steel sheet) 506. The assembly was allowed to laminate in a vacuum lamination device. Thereafter, bending work same as Example 1 was applied to get a solar cell module.

Comparative Example 2

In the case of Example 1, the VDF-HFP copolymer fluororubber containing 66% of fluorine, about 80 molar % of VDF and about 20 molar % of HFP (cross-linked site: iodine) was replaced with a VDF-HFP copolymer fluororubber containing 66% of fluorine, about 80 molar % of VDF and about 20 molar % of HFP (cross-linked site: bromine). In addition, the cross-linking was made by using, as the cross-linking agent, 6 parts by weight of calcium hydroxide and 3 parts by weight of N,N-dicyanamididene-1,6-hexanediamine per 100 parts by weight of the fluororubber. The other procedures were same as Example 1 and a solar cell module was thus prepared.

Comparative Example 3

In the case of Example 2, the cross-linking agent was not added. Except this, Example 2 was repeated to get a solar cell module.

For the solar cell modules prepared in above Examples 1 to 5 and in Comparative Examples 1 to 3 were evaluated for the following terms. The results are shown in Table 1.

(1) Conversion efficiency

The conversion efficiency of the module was determined by use of AM 1.5 light source. The conversion efficiency was evaluated with relative values supposing the conversion efficiency of Comparative Example 1 unit.

(2) Fire retardancy

Flame that was 750 degrees in temperature and generated by a burner for burning grass was applied to the module for 10 minutes, thereafter the burner flame was removed and the combustibility of the module was observed. When the burned area was small and the flame of module was put out immediately after removing the burner flame, the fire retardancy was judged "Good (G)"; when the burned area was 1 meter length or longer or self-extinguishing was not observed after removing the burner flame, the fire retardancy was judged "Poor (P)"; and when the condition was between (G) and (P), the fire retardancy was judged "Fair (F)".

(3) Weatherability

The solar cell module was charged into Dew Cycle Weather-O-Meter, and an accelerated weathering test was performed with a cycle of light irradiation and rain: the change in appearance after 5000 hours was observed. When no change was observed, the weatherability was judged "Good (G)".

(4) Heat resistance

The solar cell module was left in an atmosphere of 150°C for 24 hours and the change in appearance was observed. When no change was observed, the weatherability was judged "Good (G)".

(5) Creep resistance

The solar cell module was stood vertically in an oven at a temperature of 100°C and left for a week. Observation was made to check whether the module was crept and peeling occurred or not. When creep or peeling was observed, the creep resistance was judged "Poor (P)"; if not, judged "Good (G)".

(6) Temperature cycle

A temperature cycle consisting of -40°C for one hour and 85°C for one hour was repeated 50 times. After the run, the solar cell module was observed for change of appearance. If no change was observed, the temperature cycle was judged "Good (G)".

(7) Temperature-humidity cycle

A temperature-humidity cycle consisting of -40°C for one hour and 85°C at relative humidity of 85% for 4 hours was repeated 20 times. After the run, the solar cell module was observed for change of appearance. If no change was observed, the temperature cycle was judged "Good (G)".

(8) Humidity resistance

The solar cell module was provided in an atmosphere of 85 °C and 85% relative humidity and the irradiation was applied by a solar simulator; pseudo sunlight was irradiated on the light receiving surface. After 24 hours, performance of the solar cell was evaluated in terms of the relative lowering of the conversion efficiency; photo deterioration of the photovoltaic element was excluded from the evaluation.

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Table 1

	Conversion efficiency	Fire retardancy	Weather ability	Heat resistance	Creep resistance	Temperature cycle	Temperature-humidity cycle	Humid resistance
Example								
1	1.05	G	G	G	G	G	G	0.02
2	1.05	G	G	G	G	G	G	0.02
3	1.05	G	G	G	G	G	G	0.02
4	1.05	G	G	G	G	G	G	0.02
5	1.05	G	G	G	G	G	G	0.02
Comp. Example								
1	1	P	G	EVA turned yellowish	G	G	G	0.37
2	0.81	G	G	G	G	G	G	0.05
3	0.94	G	G	G	P	G	G	0.02

As is apparent from Table 1, the solar cell modules of Examples 1 to 5 that have the fillers of cross-linked products of fluororubber derived from vinylidene fluoride and hexafluoropropylene are excellent in fire retardancy; and they are also excellent in weatherability and heat resistance as proved by the weatherability test and heating test where no yellowing, cloudiness, and deformation of the resin were observed. Furthermore, the cross-linked fluororubbers showed excellent characteristic in the creep test at the elevated temperature. In the temperature cycle test and temperature-humidity cycle test that suppose severe outdoor service conditions, no changes in appearance were observed. The fluororubbers proved to be excellent in moisture resistance by preventing lowering of the conversion efficiency by limiting the effect of moisture on the elements to minimum extents. In contrast, Comparative Example 1, where EVA, suitably used conventionally, was used and above severe tests were performed, showed high combustibility in particular; fire retardancy was not realized with the thickness tested in Comparative Example 1. There were also problems of substantial yellowing due to heat and low moisture resistance. Fire retardancy and heat resistance were lower in Comparative Example 1 than other cases.

In Comparative Example 2, where bromine was the site of cross-linking in the tested fluororubber, initial conversion efficiency of the fluororubber of cross-linked polyamine was proved to be low.

In Comparative Example 3, where not cross-linked rubber was used, creep resistance was poor although deterioration in the weatherability test was not observed and the problem of interface peeling in the cycle tests did not occur; the filler deformed and crept easily at the elevated temperature and the shape just after the lamination was difficult to be maintained. Thus, it is essential to cross-link for using the fluororubbers as the filler of solar cell module.

The solar cell module and its production according to the present invention are not limited by above Examples in any way, and can be, of course, modified in various manners within the scope of the spirit of the invention.

In the solar cell module according to the present invention in which covering material provided on the surface of incident light side of a photovoltaic element and comprising two layers comprising a transparent filler and a transparent surface sheet provided at upmost outer surface of the filler wherein the filler comprises a cross-linked multi-component copolymer containing 60 to 80% of fluorine and containing vinylidene fluoride and hexafluoropropylene as the major components; and the surface sheet comprises a film of 40 to 60% fluorine content. Thereby, the long term reliability of the surface covering material, which was a problem conventionally, in the outdoor service has been substantially improved including fire retardancy, weatherability, heat resistance, and creep resistance.

The object is to provide a light-transmissive resin sealed semiconductor that is excellent in weatherability, heat resistance and fire retardancy, limits the performance deterioration of photovoltaic element for a long term due to moisture permeation to an minimum extent, has rubber elasticity necessary for protecting the semiconductor element, and has a surface covering material that is incombustible or fire retardant. This object is achieved by a construction wherein a covering material provided on the surface of the incident light side of photovoltaic element 101, comprises a transparent filler 102 that is a cross-linked multi-component copolymer containing fluorine and vinylidene fluoride and hexafluoropropylene as the major components.

Claims

1. A light-transmissive resin sealed semiconductor comprising a covering material provided on the surface of incident light side of a photoelectric transducer and comprising a cross-linked multi-component copolymer containing vinylidene fluoride and hexafluoropropylene as the major components.
2. A light-transmissive resin sealed semiconductor according to claim 1, wherein the multicomponent copolymer is a binary copolymer comprising 50 to 85 molar % of vinylidene fluoride and 15 to 50 molar % of hexafluoropropylene or a terpolymer comprising 50-x to 85-x molar % of vinylidene fluoride, 15 to 50 molar % of hexafluoropropylene and x molar % of tetrafluoroethylene (x is 1 to 30), or a mixture thereof.
3. A light-transmissive resin sealed semiconductor according to claim 1, wherein the multicomponent copolymer has bromine atom at the end of the polymer chain and is cross-linked by an organic peroxide with the cross-linking site of the bromine atom.

4. A light-transmissive resin sealed semiconductor according to claim 1, wherein the covering material contains a silane coupling agent.
- 5 5. A light-transmissive resin sealed semiconductor according to claim 1, wherein a surface film containing 40 to 60% by weight of fluorine is provided on the covering material.
6. A light-transmissive resin sealed semiconductor according to claim 5, wherein the surface film is an ethylene tetrafluoride-ethylene copolymer.
- 10 7. A light-transmissive resin sealed semiconductor according to claim 5, wherein the surface film is not subjected to drawing treatment.
8. A light-transmissive resin sealed semiconductor according to claim 1, wherein the photovoltaic element is formed with a semiconductor photoactive layer as a light converting member and a transparent conductive layer on a conductive substrate.
- 15 9. A light-transmissive resin sealed semiconductor according to claim 8, wherein the semiconductor photoactive layer is a non-monocrystalline semiconductor thin film.
- 20 10. A light-transmissive resin sealed semiconductor according to claim 9, wherein the non-monocrystalline semiconductor thin film is amorphous silicon.
11. A process for producing a light-transmissive resin sealed semiconductor in which a covering material provided on the surface of the incident light side of a photoelectric transducer comprises two layers comprising a filler and a surface film provided at upmost outer surface of the filler, the process comprising the steps of:
 - 25 a step in which a resin mainly composed of a fluorine-containing multi-component copolymer containing vinylidene fluoride and hexafluoropropylene as the major components is added with a cross-linking agent and formed into a film to prepare a filler in a sheet form; and
 - 30 a step in which the filler layer and a surface film comprising a fluororesin are laminated on the photoelectric transducer, thereafter the photoelectric transducer, the filler and the surface film are thermally bonded and simultaneously the filler is cross-linked.
12. A process for producing a light-transmissive resin sealed semiconductor in which a covering material provided on the surface of the incident light side of a photoelectric transducer comprises two layers comprising a filler and a surface film located at upmost outer surface of the filler, the process comprising the steps of:
 - 35 a step in which a resin mainly composed of a fluorine-containing multi-component copolymer containing vinylidene fluoride and hexafluoropropylene as the major components and a cross-linking agent are dissolved into a solvent and the resultant is coated on to the photoelectric transducer and thereafter allowed to dry to form a filler on the photoelectric transducer; and
 - 40 a step in which a surface film comprising a fluororesin is laminated on the filler, thereafter the filler and the surface film are thermally bonded and simultaneously the filler is cross-linked.
- 45 13. A process for producing a light-transmissive resin sealed semiconductor in which a covering material provided on the surface of the incident light side of a photoelectric transducer comprises two layers comprising a filler and a surface film provided at upmost outer surface of the filler, the process comprising the steps of:
 - 50 a step in which a resin mainly composed of a fluorine-containing multi-component copolymer containing vinylidene fluoride and hexafluoropropylene as the major components and a cross-linking agent are dissolved into a solvent to prepare a filler material and the filler material is coated on the surface film comprising a fluororesin and thereafter allowed to dry to form the filler material on the surface film in lamination; and
 - 55 a step in which the filler material and the surface film are laminated on the photoelectric transducer such that the filler material is in contact with the photoelectric transducer, thereafter the filler material and the photoelectric transducer are thermally bonded and simultaneously the filler material is cross-linked.

14. A process for producing a light-transmissive resin sealed semiconductor according to any one of claims 11 to 13, wherein the multi-component copolymer is either a binary copolymer comprising 50 to 85 molar % of vinylidene fluoride and 15 to 50 molar % of hexafluoropropylene or a terpolymer comprising 50-x to 85-x molar % of vinylidene fluoride, 15 to 50 molar % of hexafluoropropylene and x molar % of tetrafluoroethylene (x is 1 to 30), or a mixture thereof.
15. A process for producing a light-transmissive resin sealed semiconductor according to any one of claims 11 to 13, wherein the filler is cross-linked by an organic peroxide at the time of thermal adhesion.
16. A process for producing a light-transmissive resin sealed semiconductor according to any one of claims 11 to 13, wherein a silane coupling agent is added to the filler.
17. A process for producing a light-transmissive resin sealed semiconductor according to any one of claims 11 to 13, wherein the surface film is an ethylene tetrafluoride-ethylene copolymer.
18. A process for producing a light-transmissive resin sealed semiconductor according to any one of claims 11 to 13, wherein the surface film is not subjected to drawing treatment.
19. A process for producing a light-transmissive resin sealed semiconductor according to any one of claims 11 to 13, wherein the photoelectric transducer is formed by providing with a semiconductor photoactive layer as a light converting member and a transparent conductive layer on a conductive substrate.
20. A process for producing a light-transmissive resin sealed semiconductor according to any one of claims 11 to 13, wherein the semiconductor photoactive layer is a non-monocrystalline semiconductor thin film.
21. A process for producing a light-transmissive resin sealed semiconductor according to any one of claims 11 to 13, wherein the non-monocrystalline semiconductor thin film is amorphous silicon.

FIG. 1

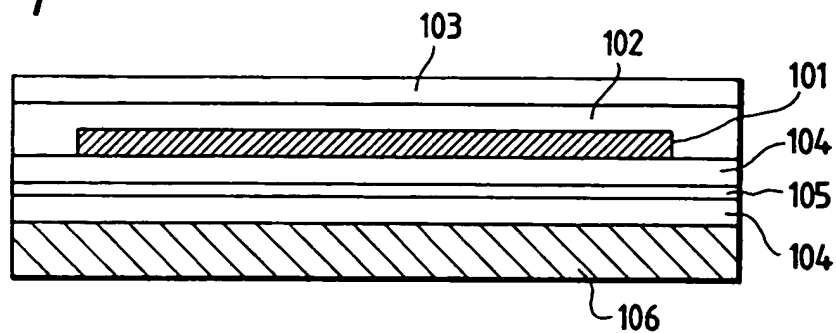


FIG. 2A

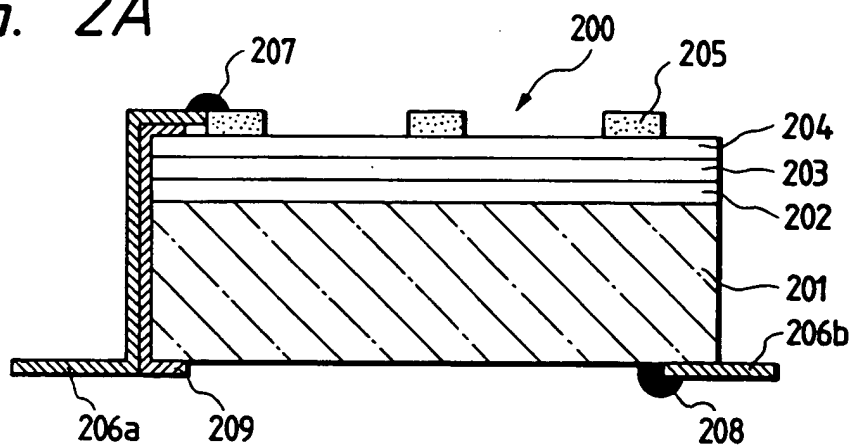


FIG. 2B

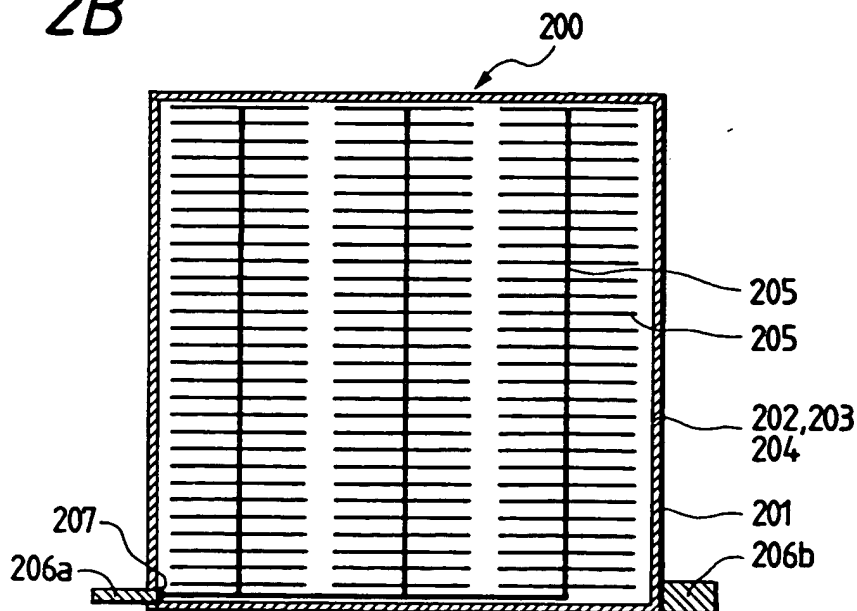


FIG. 3

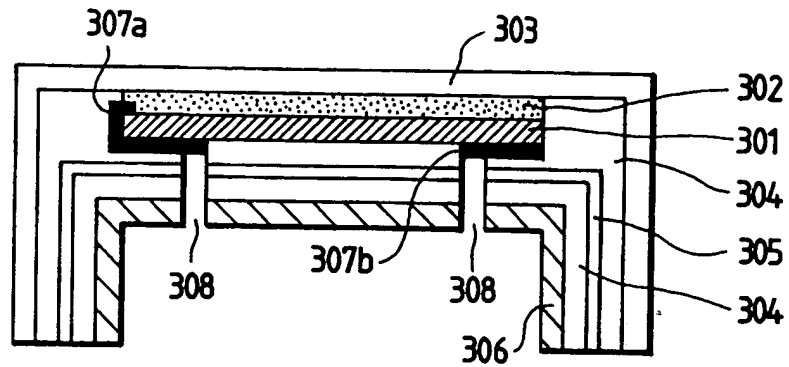


FIG. 4

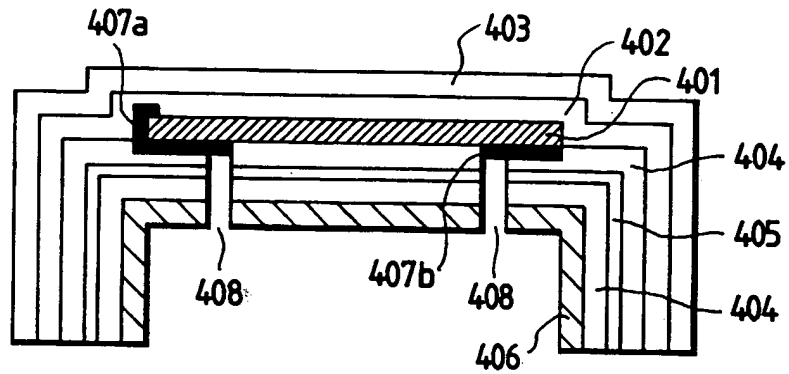


FIG. 5

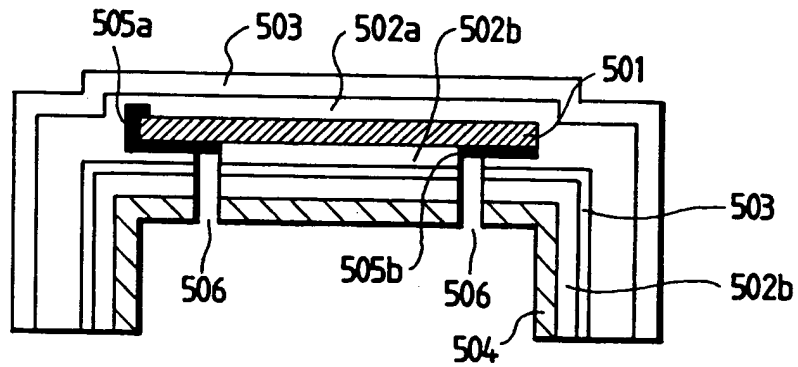
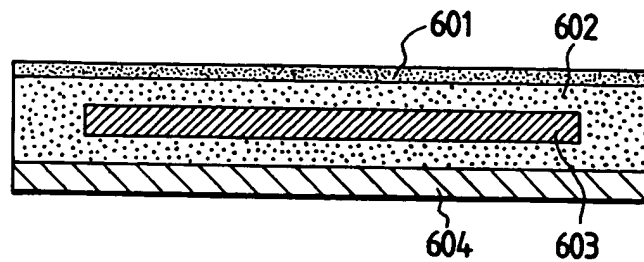


FIG. 6



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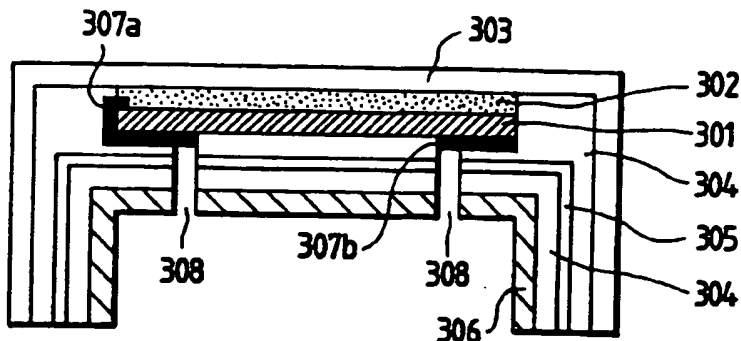
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(54) Light-transmissive resin sealed semiconductor and production process thereof

(57) The object is to provide a light-transmissive resin sealed semiconductor that is excellent in weatherability, heat resistance and fire retardancy, limits the performance deterioration of photovoltaic element for a long term due to moisture permeation to an minimum extent, has rubber elasticity necessary for protecting the semiconductor element, and has a surface covering material that is incombustible or fire retardant. This

object is achieved by a construction wherein a covering material provided on the surface of the incident light side of photovoltaic element 101, comprises a transparent filler 102 that is a cross-linked multi-component copolymer containing fluorine and vinylidene fluoride and hexafluoropropylene as the major components.

FIG. 3



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EUROPEAN SEARCH REPORT

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EP 95 10 6451

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP 0 507 468 A (DOW CORNING) * column 5, line 9 - line 10 * * column 9, line 23; claims 1,3,8 *	1,2,4	H01L31/048 H01L31/18
E	EP 0 658 943 A (CANON KK) * the whole document *	1-21	
A	JP 01 271 709 A (SUMITOMO ELECTRIC IND LTD) 30 October 1989	1	
A	JP 05 186 732 A (MITSUBISHI RAYON CO LTD) 27 July 1993	1	
A	JP 60 066 871 A (KUREHA KAGAKU KOGYO KK;OTHERS: 01) 17 April 1985	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			H01L
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 11 March 1998	Examiner Vancraeynest, F
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